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The analyses show the soils in both plats to be well supplied with the essential constituents, with the exception of phosphoric acid. This, while about the average in plat II, seems to have become considerably depleted in the plat kept continuously in wheat.

It will be interesting in this connection to note the product of grain during the eighteen years that the experiment continued. The following figures are as published in bulletin No. 71 of the Experiment Station, excepting for the last year, which is from press bulletin No. 1. The year of harvest and the yield in bushels of grain are given:

1881	9.00	1887, winter-killed.		1893	11.65
1882	47.00	1888	30.31	1894	6.05
1883	28.19	1889	37.00	1895, winter-killed.	
1884	37.00	1890	22.90	1896	24.85
1885	12.30	1891	30.75	1897	4.43
1886, winter-killed.		1892	31.30	1898	9.77

The total yield for the eighteen years was 342.5 bushels, an average of nineteen bushels per acre. This period includes three years in which the crop was winter-killed, and two more in which it was partially winter-killed. The soil is an upland, and would be regarded as of only moderate fertility, in view of which the yield obtained must be regarded as quite satisfactory. It will be noticed that during the last third of the period the product was materially less than previously, but whether this is due to soil exhaustion or merely to exigencies of the season must be left undecided.

The analyses of soil given above were made for me by Mr. A. G. Adjemian.

SILICA CEMENT MORTARS.

BY W. TWEEDDALE, TOPEKA.

Read before the Academy, at McPherson, December 29, 1899.

Cement plaster, a product of Kansas extensively used instead of lime mortar for plastering the inside of buildings, has been fully described in the fifth volume of report of the University Geological Survey of Kansas. I desire in the same line to present to you, for your information, another Kansas product which gives promise of being even of greater value as a constituent of mortar; which, possessing hydraulic properties, combines economy in cost with adaptability to all classes of masonry or concrete construction, from the heaviest foundation to the finest statuary. In said report it is termed volcanic ash; it is found of different degrees of purity, in practically inexhaustible quantities in a number of places in Kansas; it consists of silica, nearly white in color, and under the microscope appears to be in thin, transparent scales, overlapping each other, instead of, as in the case of grains of sand, being rounded, irregular particles.

To understand the value of silica as an ingredient of cement mortar, it will be of interest and tend to clearness to explain the characteristics and distinguishing differences, not only between lime mortar and cement mortars, but also between cement mortars of different kinds. These differences are both chemical and physical.

Lime, as a constituent of lime mortar, is an oxide of lime manufactured from a carbonate of lime, as limestone, chalk, or marble, by driving off the carbonic acid by means of heat in especially prepared kilns. This lime, when slaked with water and mixed with sand, constitutes lime mortar, the proportioning of the ingredients and mode of manipulating them being varied to suit the required uses.

The qualities of a good mortar are that it will "set" or harden into a substance of great strength; that it will adhere firmly to the surfaces which it joins together; and that it will preserve its hardness and strength under atmospheric influences. The setting of both lime and cement mortars is due to chemical changes in the mass of the mortar; it is, however, of an entirely different nature in the case of lime and cement mortars. In the case of lime mortar, the setting is due to the absorption from the atmosphere of carbonic-acid gas, which is absorbed by and combines chemically with the calcium of the hydrate of lime, forming carbonate of lime, and at the same time giving off water. This setting of lime mortar is dependent upon access to the atmosphere, from which it obtains carbonic acid. The hardening, therefore, must be from the outside and extend inwards at diminishing rates; this of necessity precludes the use of lime mortar for masonry under water. The giving off of water in the setting of lime mortar explains why walls built with lime mortar remain damp for such a length of time, rendering newly-built houses unhealthy.

Cement possessing hydraulic properties is manufactured from limestone or marl containing about one-fifth part of clay; this clay consists of alumina and silica.

There are two kinds of cement, natural and artificial (or Portland). Since these cements will not slake in water, they will require to be ground. While both these cements will set under water and harden throughout their whole mass, they possess distinct characteristics, both chemical and physical. Natural cements are those in which the burning has not been carried to the point of vitrification, while artificial (or Portland) cements are those in which this has been done. The quality of the cement is also affected by the proportions of the ingredients and the mode of manipulation. The underburning of the natural cements merely drives off the carbonic acid from the limestone, and changes the clay to a substance akin to brick, the result being in the nature of a mechanical mixture, corresponding to that of lime with pozzuolana, forming the hydraulic lime of the Romans and of the early English engineers. The burning to vitrification of a properly proportioned mechanical mixture of carbonate of lime and clay effects a chemical combination of the constituents forming calcium aluminates and calcium silicates, the quick setting being due to the aluminates and the strength to the silicates.

Examined under a microscope, the physical appearance of natural cement is a mass of nodular particles analogous to that of sand, while Portland cement appears to be a mass of overlapping and interlacing scales.

Mortar consists of an aggregate of sand mixed with a cementing substance, as lime or cement, with suitable quantity of water to bring it to the desired degree of consistency, as the voids between the sand particles are nearly one-half the volume of the sand. Absolute density will only be obtained when that quantity of cement is used, or the mortar is cement 1, sand 2. With lime as the cement material, the case is somewhat different, as the water adds considerable to the volume of the hydrate of lime; hence, the filling of the voids will be attained with less than that quantity of lime. In practice, less than one-half volume of cement will also serve; the usual practice for good work is to make mortar in proportion of 1 to 3.

Portland cement is ground to a certain prescribed fineness: (1) Because the coarser particles do not set, but remain inert, as so much sand. (2) Because the finer the particles the greater surface of sand they will cover.

To make a strong and reliable cement mortar there should be sufficient cement to fill the voids of the sand, and it should be evenly distributed in the mortar. By careful mixing, less cement than 1 to 3 will give fairly good results; but with the ordinary workman it is not safe to do so, for which reasons it is in many cases necessary to use a cement mortar of greater strength than is required. To overcome this unnecesary cost it has been sought to use a portion of lime mixed with the cement.

For reasons above given of the different causes of setting of lime and cement, this has not been found to be satisfactory; hence, it is extremely desirable to devise some method of making a mortar combining as nearly as possible the low cost of lime mortar with the strength and durability of cement mortar, suited to the special requirements. To meet this demand, F. L. Smidth, C. E., of Copenhagen, invented a process that satisfies these requirements when the conditions allow of the use of a mortar of less strength than would be obtained with proportion of one to three. This process consists in mixing cement and sand in the requisite proportions, and then in a special mill pulverizing them to a fine powder. This product is termed "sand cement," and is then used as ordinary Portland cement, when mixed with the usual proportions of sand and water to form a mortar, in which the voids of the finely ground sand are filled with cement and the voids of the coarser sand are filled with the sand cement, thus satisfying the requirements of filling the voids and also uniformly distributing the cement throughout the mass of the mortar.

Experiments made with lime mortar, hybrid mortar and cement mortars of different proportions of cement and sand gave as follows:

Briquette of lime; broke at 36 lbs.
Briquette of cement 1, lime 5; broke at 111 lbs.
Briquette of sand cement:
- cement 1, sand 28½; broke at 118 lbs.
- cement 1, sand 35; broke at 100 lbs.
- cement 1, sand 38; broke at 67 lbs.

In actual building with sand-cement mortar, the theoretical advantages above set forth have been surpassed.

A laboratory building was erected in Sweden in which sand cement was successfully used in proportions of cement 1, sand 51. The advantages obtained by the use of sand cement led to the erection of several plants in Europe, one in Brooklyn, and one at Glens Falls, N. Y. The cost of plant and the freight on sand has restricted the use of sand cement to where sand is plentiful and the building to be erected is of some magnitude. The foundation for the cathedral of St. John the Divine in New York city was of this material. The time required for grinding 2100 pounds at the Brooklyn works was one and three-fourths hours.

We found that there is the same physical difference between the form of the particles of silica and of ground sand as between those of natural cement and Portland cement; a fact that will justify us in believing that silica cement will be of greater value as an ingredient of mortars than sand cement. The fineness we found was an important factor in the value of sand cement. That as made at the Brooklyn works was ten per cent. residue in a 180-mesh sieve; while silica obtained from McPherson gave a residue of four per cent. in a 200-mesh sieve.